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CONFIDENTIAL

7 July 1958

MEMORANDUM FOR: DC/TSS/ASD

SUBJECT: Reliability of Equipment

1. These remarks are further to our talk of 1 July about the reliability of the equipment which is being obtained by ASD for field use. I have been over all of the pertinent material in my files and it is summarized below.

2. [redacted] one of our consultants and a well known authority 25X1 in the field, recommends that life tests of representative examples of the manufacture should begin as soon as production starts and should continue throughout manufacture. As an example, he has said that if one were to manufacture 100 devices at the rate of ten per month, one device per month should be life-tested. On another occasion he said that in order to secure 99% reliability in a product it would be desirable to have a pilot run of at least 100 examples, but where this is not practicable one could settle for a run of 10 or 12 examples and test them all. He also recommended that as much of the testing as possible should be put on the manufacturer. This will produce in the manufacturer an awareness of the questionable aspects of his product which can be attained in no other way.

3. I enclose for your information and file a copy of my memorandum of 19 October 1956*, reporting a visit of mine to [redacted] 25X1 which was devoted entirely to discussions of means for securing reliability of components and equipment. The basic philosophy is equally applicable to both components and equipment; and especially significant remarks with respect to equipment will be found on pages 4, 5, and 6.

* You probably read this memorandum during the course of its distribution when you were at [redacted] 25X1

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4. I shall be glad to discuss this subject further with you, also to furnish Thermofax copies of the memorandum if you wish.

[redacted] 25X1

TSS Technical Advisory Group

Att:

Copy of memo of 19 October 1956

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TSS/TAG/WSG/dg 7 July 1958

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19 October 1956

MEMORANDUM FOR: CHIEF, DD/P/TSS

SUBJECT : Electronic Equipment, Reliability of - Results of Interviews [redacted] 25X1
[redacted] 25X1

1. During the week of 8 October 1956, I had interviews with various specialists at [redacted] about the reliability of electronic equipment, that is, equipment containing vacuum tubes or transistors or both. In writing up the results of these interviews I shall adopt the same plan as I did for the interviews, namely, to discuss the various circuit components and then to draw conclusions as to the equipment in general. 25X1

2. Electronic equipment consists of some or all of the following electrical components:

Wiring
Vacuum Tubes
Transistors
Resistors
Capacitors
Inductors
Transformers

I was furnished with a rough general rule about the relative numbers of these components. This rule is

Number of resistors = 10 x number of vacuum tubes
Number of capacitors = 8 x number of vacuum tubes
Number of inductors = 5 x number of vacuum tubes
Number of transformers = 4 x number of vacuum tubes

For the purpose of this table vacuum tubes and transistors may be considered as interchangeable. Electronic equipment may also contain varistors, thermistors and other special circuit elements.

3. Wiring: Printed wiring should be used whenever possible, since it eliminates the possibility of errors which continually tend to creep in when ordinary wiring is used. It has one drawback, namely, that the soldering of leads to the printed wiring calls for special care in order to avoid the formation of points of weakness.

4. Vacuum Tubes: The vacuum tubes should be chosen carefully for the jobs they have to do, and any attempt to make a tube do too many jobs is especially to be avoided. It is very difficult to secure reliability of vacuum tubes by any kind of acceptance test, batch or otherwise, and the best opinion is that one should choose the best manufacturer possible and then rely on his experience after making sure he realizes that the utmost reliability is wanted.

The major part of available information on the life of vacuum tubes comes from "Airinc" (Aeronautical Radio, Inc.). This firm does life testing for the Armed Services and some tube manufacturers and is stated to be spending $14,000,000 a year. According to Airinc most tube failures are mechanical in nature, such as breaks in welds and embrittlement of tungsten. Welds are stressed severely by repeated cycles of heating and cooling, and tubes have been perfectly satisfactory for steady duty but have failed very quickly on duty cycles. Tungsten is brittle when cool and breaks when worked by hand, but when the working is done under an infrared lamp it withstands a great amount of punishment. Tungsten also is apt to become embrittled just through repeated heating.

The importance of being sure that tubes work within their proper limitations can hardly be overstressed, because many cases of tube failure are due to a violation of this condition. Large increases in life are obtained by running vacuum tubes somewhat below their rated conditions.

Long experience has shown the value of giving vacuum tubes a preliminary run, say, of at least 500 hours, and then selecting tubes from measurements made after this service. The tubes for the transatlantic telephone cable were run for "thousands of hours" before selection.

Persons who have had most experience in this direction advise the rejection of tubes on the tails of the distribution curve as being not the same sort of tube as those whose values cluster around the mode. There is some opinion that the inclusion of vibration in this preliminary service is effective in eliminating weak tubes.

5. Transistors: Transistors now have a high degree of reliability. In fact, I had the opinion from Mr. James H. Bridges, of the Office of the Assistant Secretary of Defense (Applications Engineering), that they are more reliable than vacuum tubes. This is the case for vacuum tubes under military conditions, but it is not yet certain that the best transistors last longer than the best vacuum tubes.

The order of reliability that has been reached can be judged from the statement that point-contact transistors have a record of one million unit-hours per failure, that is 1,000 transistors can run for 1,000 hours before a single failure occurs. This is the same order of life as for high quality vacuum tubes in service in the Bell system. Grown alloyed transistors have a record of from 150,000 to 200,000 unit-hours per failure.

In transistors, as in vacuum tubes, a preliminary run of at least 500 hours, followed by screening, adds to the reliability of the product.

In ordering transistors from a manufacturer it should be specified very carefully that they should have the highest degree of reliability. The name of the General Electric Company was given to me as an outstanding commercial supplies of such transistors.

An additional advantage of using transistors is that the small amount of power involved in their use puts the other components practically under shelf life conditions.

6. Resistors: Resistors are of two kinds - composition and wire-wound.

Composition resistors of outstanding quality are made by the Allen-Bradley Company and the International Resistance Corporation. They are extraordinarily good from the standpoint of catastrophic failure and have a record of practically no opens or shorts if properly used. However, they drift in value in either direction up to 20% or 25% from their rated values. In general the drift is of the same order of magnitude as the original accuracy stated in the specification of the resistors.

Wire-wound resistors are more liable to catastrophic failure, probably on account of electrolysis. The wire involved is fine, sometimes as small as # 51 (.00088 inch), and a small spot of

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7. Capacitors: Capacitors, originally called condensers, are of two kinds - non-electrolytic and electrolytic. In non-electrolytic capacitors the dielectric is sometimes mica but generally paper, although research and development on other dielectrics is very active. Electrolytic condensers with a liquid electrolyte are generally aluminum, but the present preference is for tantalum. The latest and most promising type of electrolytic condenser is a tantalum condenser with a dry electrolyte consisting of manganese dioxide.

All of the specialists with whom I talked named Sprague Electric Co., of North Adams, Mass., as the best maker of capacitors.

8. Paper Condensers: Paper condensers have been under development for many years and now can be made with a high degree of reliability, namely, less than one failure in 100,000 during the condenser life. When extreme reliability is required, the precautions taken have sometimes been such that every other condenser in a production run was tested to destruction in order to ascertain the quality of the run. In making paper condensers for the transatlantic telephone cable three times as many of the highest quality paper condensers were made as were to be used. These were put on six months life test and were then measured and the best one-third selected.

9. Aluminum Condensers: Extensive experience on aluminum condensers has been accumulated since 1928, and it is possible to make such condensers with a life of as much as 15 years. In order to get this life the design has to be good and the manufacture has to be well controlled. Here again it is highly important to specify to the manufacturer that the utmost in reliability is desired. One consultant was strong for 100% screening tests, that is, to run the condensers for 500 hours under voltage and then to reject the tails of the distribution curve. The manufacture should be such that the rejects are few because a large number of rejects means poor control. It is important to have the temperature of use as low as possible, because the life of the capacitor

halves for each 10° C. rise in temperature.

10. Tantalum Electrolytic Condensers: Condensers of tantalum filled with liquid electrolyte have been known for some time, but it is only for the last five or six years that extensive manufacturing information on them has been accumulated. It is now felt that the product with the longest life and greatest reliability in these condensers is the condenser with the solid electrolyte mentioned above. These condensers have now been on life test for 10,000 hours and a good degree of reliability has been established.

11. Transformers and Inductors: The chief defect limiting the life of these circuit elements is wire corrosion. When it is realized that many of these items are made with # 51 wire having a diameter of .00088 inch it is realized that a very small amount of corrosion can sever the wire.

12. General Conclusions: From all my talks the following principles emerged:

a) The electrical design should use all circuit elements within their ratings, and preferably under their ratings. The equipment should still work for the maximum drift in the properties of all of the components.

b) The design should be mechanically sound - components should not depend upon their leads for support and leads should not be bent or soldered near the point of entry.

c) Adequate arrangements should be made for the dissipation of heat.

d) Components should be procured from manufacturers having the longest experience with the item in question and the highest degree of probity.

e) A reliability requirement should be put in the specifications for components but the manufacturer should not be tied down to any particulars that can be avoided.

f) Insist on adequate life tests and, since there is no real accelerated life test, these tests should be begun as soon as possible under the conditions of use.

g) The manufacture should be well controlled, that is, the desired quality should be secured with as small a number of rejects as possible.

h) For the highest reliability, screen the product after a simulated service run.

[redacted] 25X1

TSS/Technical Advisory Group

TSS/TAG:wsg/jlp (26 October 1956)

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